PRELIMINARY QUALITY ASSURANCE PROJECT PLAN FOR IMPLEMENTING THE HOOD CANAL STREAM MONITORING STRATEGY

Prepared for

WRIA 16/14b Planning Unit

July 2010

Note:
Some pages in this document have been purposefully skipped or blank pages inserted so that this document will copy correctly when duplexed.

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Prepared for

WRIA 16/14b Planning Unit

Prepared by

Herrera Environmental Consultants
1220 Fourth Avenue
Olympia, Washington 98506

and

Aspect Consulting
179 Madrone Lane North
Bainbridge Isle, Washington 98110

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Introduction

This Quality Assurance Project Plan (QAPP) has been prepared by Herrera Environmental Consultants (Herrera), to generally describe the approach that will be taken to implement the long term stream water quality monitoring strategy for Hood Canal (Herrera 2010). Funding for this monitoring program has not been established so portions of the plan such as the total number and specific location of water quality and flow stations may change to meet budgetary constraints. For this reason, this QAPP discusses sampling and analysis procedures in general terms and does not portray site specific information where it has yet to be defined. This document specifically describes sampling, analysis, and quality assurance procedures pertaining to:

- Streamflow measurement
- Water quality sampling and analysis
- Sediment metal, and priority pollutant sampling and analysis
- Collection of aquatic macroinvertibrate samples

As funding becomes available and different parts of the monitoring strategy are implemented several details will need to be confirmed and included in a Final QAPP for the program, or as addendums to a Final QAPP. Specifically:

- The Tier 2 monitoring strategy, if implemented will need to be finalized (e.g. selection of stations, parameters and components).

- Specific monitoring roles, organizations involved and assignment of specific responsibilities will need to be identified.

- Specific detail on the flow monitoring equipment used at each site will need to be provided as well as detail related to field meters used and their calibration.

- Details on data evaluation methods should be added.

This QAPP was prepared in accordance with Ecology's *Guidelines for Preparing Quality Assurance Project Plans for Environmental Studies* (Ecology 2004) and generally documents the procedures that will be used during sample collection, processing, and analysis to ensure that the resultant data are scientifically and legally defensible. This information is organized within this document under the following subheadings.

- Project Description
- Project Organization and Schedule
- Quality Objectives
- Sampling Process Design
- Quality Control
- Data Management Procedures

- Audits
- Data Verification and Validation
- Data Quality (Usability) Assessment
- Data Evaluations

Project Description

The goal of this monitoring plan is to provide a database robust enough to evaluate long-term trends in water quality in Hood Canal freshwater streams as they respond to climate change and increased development. This goal will be accomplished through extensive water quality monitoring, streamflow monitoring, and targeted sampling of priority pollutants in streambed sediments and quantifying aquatic macroinvertebrate abundance and diversity. Water quality monitoring will be achieved by sampling basic water quality parameters at 11 'Tier 1' stations. (Tier 1 refers to the highest priority monitoring stations and monitoring components selected by the Planning Unit. A second tier of monitoring that could include as many as 32 additional sites (Tier 2 sites) but fewer monitoring components was also identified in the monitoring strategy. If this second tier of monitoring is funded, final decisions of which sites and monitoring components will be included in Tier 2 monitoring will be made and included in an addendum to the final QAPP that will need to be prepared for this monitoring strategy.) Tier 1 stations will be sampled six times between the middle of November and the middle of February and three times during late summer (e.g., once in July, August and September every year). Tier 2 stations, if implemented, will be monitored on a rotating four year schedule so that every Tier 2 site is monitored for one year out of every four. In the years that a Tier 2 site is selected for monitoring, sampling will occur coincident in time with sampling at the Tier 1 sites. Sediment sampling for priority pollutants will occur on a biennial basis at all of the Tier 1 stations and may occur at a subset of the Tier 2 stations. Aquatic macroinvertebrate abundance and diversity will be measured on the same streams as priority pollutant sediment samples. Flow measurements will be taken at all water quality monitoring sites whenever a sample is collected. Depending on available budget, continuous flow monitoring equipment may be installed at all Tier 1 stations. On-going water quality or flow monitoring efforts such as those conducted by the Department of Ecology (Ecology), Skokomish Tribe, or the United States Geological Survey (USGS) which already operate under an Ecology or EPA approved QAPP, will likely be incorporated into this monitoring effort. Other entities such as Mason County, Jefferson Conservation District, and Kitsap Health District may also participate in monitoring.

More in-depth summaries of these integral project components are listed below

- **Tier 1 Sites:** Tier 1 sites are located at the mouths of streams to represent the "end product" as they enter marine waters. Though this strategy does not allow for the identification of specific pollutant sources, it allows for determining if water quality concerns exist within the watershed. Tier 1 sites are chosen to provide a spatial distribution based on geology, land use and vegetation, as well as to represent varying levels of water quality and habitat degradation, in-stream flow concerns and areas of future development. Monitoring at Tier 1 sites will continue indefinitely. Sampling will occur six times between the middle of November and the middle of February, and one time in each July, August and September and October. Samples will be analyzed for conventional water quality

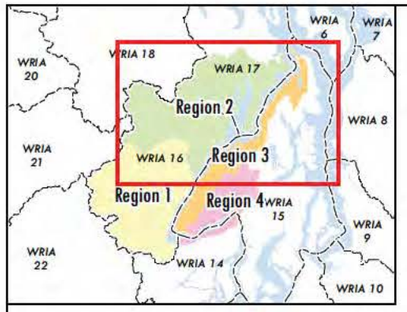
parameters. A full list of constituents can be found in the *Sampling Process Design* section.

- **Tier 2 Sites:** The purpose of the Tier 2 Stations are to augment the data gathered at Tier 1 stations by increasing spatial coverage as well as allowing for the determination of upstream conditions on several of the Tier 1 streams. To focus Tier 2 station sampling efforts, the Hood Canal watershed has been divided into four distinct sub-regions shown in figures 1 and 2. These regions were geographically determined with the intent of including 10 or more significant drainages, while remaining small enough to sample in a single day. Each year all of the Tier 2 sites within a given sub-region will be monitored concurrently with the Tier 1 Sites. Samples will be analyzed for limited suite of conventional water quality parameters. A full list of constituents can be found in the *Sampling Process Design* section.

- **Flow monitoring:** Some level of flow monitoring will be conducted at all sampling sites. At a minimum, instantaneous flow measurements will be taken whenever a sample is collected. The level of intensity of flow monitoring and equipment used will depend on funding availability. The high cost associated with installing and maintaining continuous flow gauging equipment will prohibit it from being installed at all sites. Priority will be given to Tier 1 monitoring stations for installing continuous flow measuring equipment.

- **Priority Pollutants:** Sediment samples will be collected at all Tier 1 stations on a biennial basis. Samples will be collected in late June when stream flows will have decreased enough to allow formation of good depositional areas for sediment sampling. All samples will be collected from depositional areas upstream of tidal influence. The priority pollutants selected for measurement in sediment samples include the heavy metals and the group of organic priority pollutants that is captured through analysis of the chlorinated acid herbicides and organochlorine pesticides. A full list of constituents can be found in the *Sampling Process Design* section.

- **Aquatic Macroinvertebrates:** Aquatic macroinvertebrate sampling will occur biennially at all Tier 1 sites and potentially at Tier 2 sites. Sampling should be conducted between July 1 and October 15th when these organisms are still in pre-emergent stages. Samples will be collected from riffle areas above the area of impact from tides. Macroinvertebrate abundance and diversity based on genus level classification will be used to calculate Benthic Index of Biological Integrity (BIBI) scores, based on the Puget Sound Lowlands scoring method.



LELAND LAKE
Total Phosphorus

TARBOO CREEK
Temperature

LELAND CREEK
pH, Temp, and DO

TARBOO CREEK, E.F.
Temperature

HOWE CREEK
Temperature

RIPLEY CREEK
Temperature

LITTLE QUILCENE RIVER
Temperature

DONOVAN CREEK
Temperature

BIG QUILCENE RIVER
Temperature

KINMAN CREEK
Dissolved Oxygen

MARTHA JOHN CREEK
Dissolved Oxygen

GAMBLE CREEK
Dissolved Oxygen

JUMPOFF JOE CREEK
Dissolved Oxygen

GAMBLE CREEK
Temperature

MARPLE CREEK
Temperature

DUCKABUSH RIVER
Temperature

DOSEWALLIPS RIVER
Temperature

SEABECK CREEK
Dissolved Oxygen

BIG BEEF CREEK
Dissolved Oxygen

BIG BEEF CREEK
Temperature

STAVIS CREEK
Fecal Coliform & Dissolved Oxygen

FULTON CREEK
Temperature

BOYCE CREEK
Fecal Coliform & Dissolved Oxygen

BIG ANDERSON CREEK
Fecal Coliform & pH

Region 1

Region 2

Region 3

Region 4

Dabob Bay

Hood Canal

Hood Canal

Existing Water Quality Monitoring Stations:

Monitoring Agency:

- (B) BPWU
- (E) Ecology
- (J) JCCD
- (K) KCHD
- (P) PTPW
- (S) Skokomish
- (W) WDFW

Analysis Type:

- (X) Complete WQ Analysis
- (X) Fecal Coliform Only
- [X] Few/Single Parameter

Proposed "Key" Monitoring Stations

WATER COUSE/BODY NAME
Listed Parameter(s)

Category 5 Listed Waters

PNW Hydro Framework 12th-level Hydrologic Unit Boundaries

Region 2 Study Regions

Relative Rating of Potential Impact for Consumptive Water Use and Habitat Condition

- not rated/no data
- low potential
- moderate potential
- high potential

Salmonid/Bull Trout Distribution (WDFW SaSI)

SPECIES:

- Bull Trout
- Other Salmonids

Habitat Condition Rating (WSCC Salmonid Limiting Factors, modified)

- Good
- Fair
- Poor

N W E S

0 7,500 15,000 30,000 Feet

1:180,000

HERRERA ENVIRONMENTAL CONSULTANTS

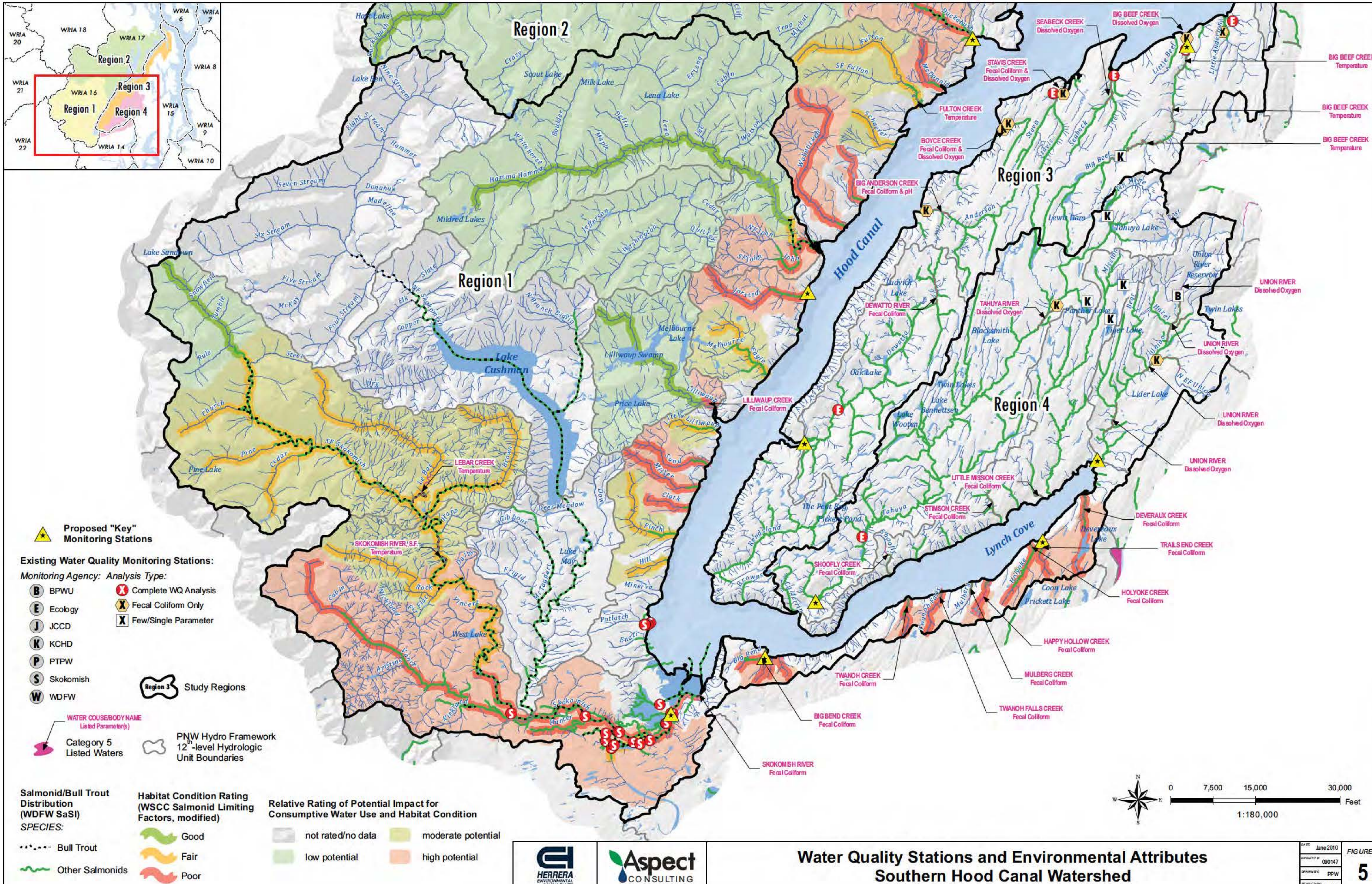
Aspect CONSULTING

Water Quality Stations and Environmental Attributes
Northern Hood Canal Watershed

DATE:	June 2010
PROJECT #:	090147
DRAWN BY:	PPW
REVISED BY:	PPW

FIGURE # 4

T:\projects_8\WRIA16\HoodCanal_SW_Mgn_Plan\Delivered\MonitoringStrategy\Bio_North.mxd



HERRERA ENVIRONMENTAL CONSULTANTS | Aspect CONSULTING

Water Quality Stations and Environmental Attributes
Southern Hood Canal Watershed

DATE: June 2010
PROJECT #: 090147
DRAWN BY: PPW
REVISED BY: PPW

FIGURE # 5

The long term goals, and specified sampling intervals require that this project be conducted over the period of multiple decades. A start date has not been determined because funding sources have not been secured. Once monitoring commences, results for this project will be published in annual reports that will present the data collected during each water year (October 1-September 30).

Project Organization and Schedule

This section typically describes the project organization and identifies key personnel and their roles, as well as details regarding project scheduling. The scope of work, responsible parties, and schedule for this project is undefined at this point. For this reason, only the roles of key personnel and general scheduling considerations are discussed.

Roles and Responsibilities

Project Manager: Responsible for the development, approval, implementation, and maintenance of the QAPP. Acts as a liaison between the Monitoring Group Managers, Field Supervision Technical Lead, and Data Quality Assurance Officer. Responsible for: maintaining records of QAPP distribution, including appendices and amendments; identifying, receiving, and maintaining study quality assurance records; coordinating with the Data Quality Assurance Officer to resolve QA-related issues. Responsible for coordinating with Monitoring Group Managers for ensuring tasks and other requirements in the contract for field implementation are executed on time and are of acceptable quality. Coordinates attendance at conference calls, training, meetings, and related study activities. Responsible for verifying the QAPP is followed and the study is producing data of known and acceptable quality. Works directly with Monitoring Group Managers to coordinate study assignments, establish priorities and schedules, and ensure the completion of high-quality studies within established budgets. Interacts with technical reviewers to assure technical quality requirements are met in accordance with QAPP specifications.

Monitoring Group Manager(s): Coordinates and oversees all monitoring under their jurisdiction. Supervises the assigned study personnel (scientists, technicians, and support staff) in providing for their efficient utilization by directing their efforts either directly or indirectly on studies. Ensures that the staff has the necessary education, experience, and/or training to perform their stated duties. Monitors and assess the quality of work. Provide guidance and technical advice to those assigned to studies by evaluating performance, implement corrective actions and provide professional development to staff, and prepare and/or review preparation of study deliverables. Works in close contact with the Project manager to ensure that technical requirements of individual group's monitoring efforts are being met in accordance with QAPP specifications as well as to coordinate schedules and priorities with other monitoring groups.

Field Supervision Technical Lead: Responsible for supervising all aspects of the sampling and measurement in the field. Works with the Project Manager and Monitoring Group Managers to: ensure uniform sampling techniques and comparability of data, coordinate sampling schedules, ensure that field data measurements are conducted in a uniform and timely manner that meet the quality objectives, determine that individual monitoring groups have necessary staff with appropriate training to conduct monitoring in adherence with QAPP guidelines.

Data Manager/Quality Assurance Officer: Responsible for the acquisition, verification, and transfer of data to the EIM database. Oversees data management for the study. Compiles data from individual Monitoring Group databases. Coordinates with Monitoring Group Managers to ensure that data is stored in a format that facilitates compiling data into a single database. Ensures data are submitted according to work plan specification. Responsible for validation and verification of data collected. Provides the point of contact to resolve issues related to the data.

Laboratory Manager(s): Responsible for supervision of laboratory personnel involved in generating analytical data for this study. Responsible for ensuring that laboratory personnel involved in generating analytical data have adequate training and a thorough knowledge of the QAPP and all SOPs specific to the analyses or task performed and/or supervised. Responsible for oversight of all operations, ensuring that all QA/QC requirements are met, and documentation related to the analysis is completely and accurately reported. Enforces corrective action, as required. Develops and facilitates monitoring systems audits.

Project Schedule

A commencement date for this monitoring project has not been determined. Before implementing this QAPP, specific project milestones and reporting deadlines should be identified.

Quality Objectives

A primary goal of this QAPP is to ensure that the data collected for this study are scientifically accurate, useful for the intended analysis, and legally defensible. To achieve this goal, the collected data will be evaluated relative to the following indicators of quality assurance:

- **Precision**: A measure of the variability in the results of replicate measurements due to random error.
- **Bias**: The systematic or persistent distortion of a measurement process that causes errors in one direction (i.e., the measured mean is different from the true value).
- **Representativeness**: The degree to which the data accurately describe the conditions being evaluated based on the selected sampling locations, sampling frequency and duration, and sampling methods.
- **Completeness**: The amount of data obtained from the measurement system. Since this monitoring strategy entails collection of data over an indefinite period, there is no test or endpoint for completeness. This quality objective is no discussed further in this QAPP.)
- **Comparability**: The ability to compare data from the current study to data from other similar studies, regulatory requirements, and historical data.

Measurement quality objectives (MQOs) are performance or acceptance criteria that are established for each of these quality assurance indicators. The specific MQOs to be used for this study are described below in separate subsections for hydrologic and laboratory data, respectively.

Measurement Quality Objectives for Hydrologic Data

Hydrologic monitoring will involve measurements of water level (stream stage) and velocity, as well as cross-sectional area measurements and rating curve estimation. MQO's vary depending on the specific method used for each site. MQO's for these measurements are defined for the following data quality indicators; bias, representativeness, completeness, and comparability.

Bias

The bias of hydrologic monitoring data will be assessed based on comparisons of monitoring equipment readings to an independently measured "true" value. In this case the true value will be

derived from manual measurements of water level that are obtained from a staff gauge at each monitoring location. These manual measurements will be made 10 times per year in conjunction with routine visits to each monitoring location (see next section).

If the monitoring equipment is not affected by drift or other operational problems, the difference between the equipment's reading and the manual measurement of water level ("instrument drift") should remain at zero over time and varying water depths. Therefore, bias in these data will be assessed based on the change in the instrument drift value relative to all previous measurements. Specifically, a change in the instrument drift value of plus or minus 2 standard deviations relative to the mean from all previous measurements will trigger an assessment of the monitoring equipment to determine proper functioning.

At least six times per year, discharge will be measured using the methods listed in the "hydrologic monitoring" section below. These measurements will serve as calibration points for developing and assessing changes in the rating curve.

Several of flow gauging stations that will be used by this monitoring effort are gauged by USGS, Ecology, or public works agencies. These groups will follow their own calibration protocols.

Representativeness

The multi decade duration of this sampling project will provide measurements that represent a wide range of flow and meteorological conditions. Representativeness will be ensured by adequate sample size over a sufficient time span, and by employing consistent and standard sampling procedures.

Comparability

Standard measurement procedures will be applied in this study to meet the goal of data comparability.

Measurement Quality Objectives for Water Quality Data

Quality assurance objectives for laboratory data are defined for the following data quality indicators: precision, bias, representativeness, completeness, and comparability. The specific MQOs that have been identified for this project are described below and summarized in Table 1. Note that the term **"**reporting limit" in this document refers to the practical quantification limit established by the laboratory, not the method detection limit.

Precision

In this study, overall data quality will be based on analytical precision. Analytical precision will be assessed by laboratory splits of samples, matrix spikes, and laboratory control samples (see below, under Bias). These will be assessed using relative percent difference (*RPD*).

$$RPD = \left(\frac{\left| C_1 - C_2 \right|}{C_1 + C_2} \right) \times 200\%$$

Where: RPD = Relative percent difference

C_1 and C_2 = Concentration values.

If split sample concentrations are both within 5 times the reporting limit, the RPD goal for all parameters is < 2 times the reporting limit. If either of the split samples is at or below the reporting limit, the MQO cannot be calculated. *RPD* values exceeding those described here and in Table 1 will trigger an assessment as to whether there are any problems with the laboratory methodology, which might warrant corrective actions.

Bias

Bias will be assessed based on analyses of method blanks, matrix spikes, and laboratory control samples (LCS).

Field Sample Bias

Travel blank results greater than two times the laboratory reporting limit (RL) will be flagged as a de facto detection limit (*U*), and associated project samples within 5 times the de facto reporting limit will be labeled with a *J*. For details regarding remedial steps if contamination from field equipment is detected, refer to the *Verification and Validation* section.

Laboratory Bias

The values for method blanks will not exceed the reporting limit. The percent recovery of matrix spikes and the percent recovery of LCS are described in Table 1 for all applicable parameters. Percent recovery for matrix spikes will be calculated using the following equation:

$$\%R = \frac{(S - U)}{C_{sa}} \times 100\%$$

Where: %R = Percent recovery

S = Measured concentration in spike sample

U = Measured concentration in unspiked sample

C_{sa} = Actual concentration of spike added.

If the analyte is not detected in the unspiked sample, then a value of zero will be used in the equation.

Table 1. Measurement quality objectives for water quality data.

Analyte Group	Analyte	Method	Laboratory Method Blank [a]	Travel Blank[a]	Control Standard Recovery	Matrix Spike Recovery	Laboratory and Field Duplicate *RPD* [c]
Conventional Paramters	**Field Analysis**						
	pH	Field Meter	N/A	N/A	N/A	N/A	.05 SU
	Dissolved Oxygen	Field Meter	N/A	N/A	N/A	N/A	≤10% or ±2 × RL
	Temperature	Field Meter	N/A	N/A	N/A	N/A	N/A
	Conductivity	Field Meter	N/A	N/A	N/A	N/A	≤25% or ±2 × RL
	Turbidity	Field Meter	N/A	N/A	N/A	N/A	≤25% or ±2 × RL
	Laboratory Analysis						
	BOD_{20}	Membrane Electrode	≤RL	≤RL	NA	NA	NA
Bacteria	Fecal Coliform	Multiple Tube Fermentation	≤RL	≤RL	NA	NA	≤35% or ±2 × RL
Nutrients	Total phosphorus	Digestion / Colorometric	≤RL	≤RL	90–110%	75–125%	≤20% or ±2 × RL
	Ortho-phosphate phosphorus	Colorometric	≤RL	≤RL	90–110%	75–125%	≤20% or ±2 × RL
	Total nitrogen	Digestion / Colorometeric	≤RL	≤RL	90–110%	75–125%	≤20% or ±2 × RL
	Nitrate + nitrite nitrogen	Colorometric	≤RL	≤RL	90–110%	75–125%	≤20% or ±2 × RL

[a] If criteria is not met associated blank concentration is defined as the new reporting limit and project sample data within 5 times this de facto reporting limit are flagged with a *J*.

[c] The relative percent difference must be less than or equal to the indicated percentage for values that are greater than 5 times the reporting limit. RPD must be and ±2 times the reporting limit for values that are less than or equal to 5 times the reporting limit.

SU=standard unit

NA = not applicable.

RL = reporting limit.

RPD = relative percent difference.

Percent recovery for LCS will be calculated using the following equation:

$$\%R = \frac{M}{T} \times 100\%$$

Where: %R = Percent recovery
M = Measured value
T = True value.

Representativeness

The multi decade duration of this sampling project will provide samples that represent a wide range of water quality, flow and meteorological conditions. Representativeness will be ensured by adequate sample size over a sufficient time span, and by employing consistent and standard sampling procedures.

Comparability

Standard sampling procedures, analytical methods, units of measurement, and reporting limits will be applied in this study to meet the goal of data comparability. Monthly sampling events at Tier 1 sites will be scheduled to occur on the same day, to ensure that samples from a given sampling event are as comparable as possible between streams. Tier 2 sites will be sampled to insure all those within a specific subregion are sampled during the same day.

Measurement Quality Objectives for Sediment Quality Data

Quality assurance objectives for sediment quality data results received from the laboratory are expressed in terms of precision, bias, representativeness, completeness, and comparability. The specific MQOs that have been identified for this project are described below and summarized in Table 2. Note that the term **"**reporting limit" in this document refers to the practical quantification limit established by the laboratory, not the method detection limit.

Precision

In this study, overall project data quality will be based on analytical precision. Analytical precision will be assessed by laboratory splits of samples, matrix spikes, and laboratory control samples (see below, under Bias). These will be assessed using relative percent difference (*RPD*).

$$RPD = \left(\frac{\left| C_1 - C_2 \right|}{C_1 + C_2} \right) \times 200\%$$

Where: *RPD* = Relative percent difference
C_1 and C_2 = Concentration values.

If split sample concentrations are both within 5 times the reporting limit, the RPD goal for all parameters is < 2 times the reporting limit. If either of the split samples is at or below the reporting limit, the MQO cannot be calculated. *RPD* values exceeding those described in Table 2 will trigger an assessment as to whether there are any problems with laboratory methodology, which might warrant corrective action.

Bias

The values for method blanks will not exceed the reporting limit. The percent recovery of matrix spikes and the percent recovery of LCS are described in Table 2 for all applicable parameters. Percent recovery for matrix spikes will be calculated using the following equation:

$$\%R = \frac{(S - U)}{C_{sa}} \times 100\%$$

Where: %R = Percent recovery
S = Measured concentration in spike sample
U = Measured concentration in unspiked sample
C_{sa} = Actual concentration of spike added.

If the analyte is not detected in the unspiked sample, then a value of zero will be used in the equation.

Percent recovery for LCS will be calculated using the following equation:

$$\%R = \frac{M}{T} \times 100\%$$

Where: %R = Percent recovery
M = Measured value
T = True value.

Representativeness

Annual collection of sediment will allow for a sample representative of the full year of sediment conditions. Sample representativeness will be ensured by employing the standard sampling procedures which require sampling from a specifically sized sampling area (e.g., 0.19 m^2).

Comparability

Standard sampling procedures, analytical methods, units of measurement, and reporting limits will be applied in this study to meet the goal of data comparability. The results will be tabulated

Table 2. Measurement quality objectives for sediment quality data.

Parameter Group	Parameter	Laboratory Method Blank [a]	Control Standard Recovery	Surrogate Recovery	Matrix Spike Recovery [b]	Laboratory and Field Duplicate *RPD* [c]
Conventional Parameters	Total organic carbon	≤RL	75 – 125%	NA	75 – 125%	≤35% or ± 2X RL
Metals	Metals captured through EPA method 200.7	≤RL	80 – 120%	NA	75 – 125% 80 – 120%	≤20% or ± 2X RL
Chlorinated Herbicides	Chlorinated herbicides captured through analysis method 8151	≤RL	Laboratory established control limits	Laboratory established control limits	Laboratory established control limits	Laboratory established control limits for laboratory duplicate; ≤35% for field duplicate
Chlorinated Pesticides	Chlorinated herbicides captured through analysis method 8081	≤RL	Laboratory established control limits	Laboratory established control limits	Laboratory established control limits	Laboratory established control limits for laboratory duplicate; ≤35% for field duplicate

[a] If criteria is not met associated blank concentration is defined as the new reporting limit and project sample data within 5 times this de facto reporting limit are flagged with a J.

[b] For inorganics, the CLP Functional Guidelines state that the spike recovery limits do not apply when the sample concentration exceeds the spike concentration by a factor of four or more (Ecology 2005).

[c] The relative percent difference must be less than or equal to the indicated percentage for values that are greater than 5 times the reporting limit. RPD must be and ±2 times the reporting limit for values that are less than or equal to 5 times the reporting limit.

RL = reporting limit.

RPD = relative percent difference.

in standard spreadsheets to facilitate analysis and comparison with sediment quality threshold limits where appropriate.

Measurement Quality Objectives for Aquatic Macroinvertebrate Sorting and Classification

The following was excerpted from EPA's Wadeable Stream Assessment QAPP (EPA 2004).

Precision

Taxonomic precision will be quantified by comparing whole-sample identifications completed by independent taxonomists or laboratories. Accuracy of taxonomy will be qualitatively evaluated through specification of target hierarchical levels (e.g., family, genus, or species); and the specification of appropriate technical taxonomic literature or other references (e.g., identification keys, voucher specimens). To calculate taxonomic precision, 10 percent of the benthic macroinvertebrate samples will be randomly-selected for re-identification.

Comparison of the results of whole sample reidentifications will provide a Percent Taxonomic Disagreement (PTD) calculated as:

$$PTD\left[1-\left(\frac{Comp_{pos}}{N}\right)\right]\times 100$$

where *comp pos* is the number of agreements, and *N* is the total number of individuals in the larger of the two counts. The lower the PTD, the more similar are taxonomic results and the overall taxonomic precision is better. A measurement quality objective (MQO) of 15% is recommended for taxonomic difference or disagreement (overall mean 15% is acceptable based on similar projects). Individual samples exceeding 15% are examined for taxonomic areas of substantial disagreement, and the reasons for disagreement investigated.

Sample enumeration is another component of taxonomic precision. Sample enumeration agreement will be checked with the same 10% of samples used to check taxonomic precision. Final specimen counts for samples are dependent on the taxonomist, not the rough counts obtained during the sorting activity. Comparison of counts is quantified by calculation of percent difference in enumeration (PDE), calculated as:

$$PDE=\left(\frac{\left|Lab\,1 - Lab\,2\right|}{Lab\,1+Lab\,2}\right)x\,100$$

An MQO of 5% is recommended (overall mean of ≤5% is acceptable). Individual samples exceeding 5% are examined to determine reasons for the exceedance. Corrective actions for

samples exceeding these MQOs can include defining the taxa for which re-identification may be necessary (potentially even by third party), for which samples (even outside of the 10% lot of QC samples) it is necessary, and where there may be issues of nomenclatural or enumeration problems. Taxa lists will be changed when disagreements are resolved by a third party. Specific MQO's for macroinvertebrate sorting are presented in Table 3.

Table 3. Measurement Quality Objectives for Aquatic Macroinvertebrate Sorting and Identification.

Measurement	Precision	Accuracy[a]	Completeness
Sort and Pick	95%	90%	99%
Identification	85%	90%	99%

[a] Taxonomic accuracy, as calculated using

Bias

There is inherent bias in this sampling design, because the sampling sites were not randomly selected. Additionally, samples will be collected at the same time each year which introduces a seasonal bias as well. These biases are not problematic, however, because this purpose of this monitoring program is to track the trends observed at individual sites over a period of time. Potential sampling bias will be mitigated by collecting a composite of three samples at each site.

Representativeness

The multi decade duration of this sampling project will provide samples that represent a wide range of water quality and flow conditions. Sample representativeness will be ensured by employing the standard sampling procedures which require sampling from a specifically sized sampling area (e.g., 0.19 m^2). Representativeness will also be ensured by analyzing a composite of three samples for each site location.

Comparability

For all measurements, reporting units and format are specified, and incorporated into standardized data recording forms, and documented in the information management system. Comparability is also addressed by providing results of QA sample data, such as estimates of precision and bias, conducting methods comparison. If some incompatibility between sampling crews comes to light, the data will be rejected.

Experimental Design

This section provides an overview of the experimental design that will be used for this study. As mentioned above, site selection, site specific flow measurement technique, and specific sites that will be included for more intensive monitoring (e.g. biennial sediment sampling) is not fixed, and will likely change prior to implementing this QAPP. What is presented below provides the best possible prediction of the experimental design.

Study Site Description

The WRIA 16 planning group and representatives from Kitsap County worked with Herrera staff to select the most important sites to be included in a long-term monitoring plan for the Hood Canal Watershed. Streams were selected to provide a spatial distribution based on geology, land use and vegetation, as well as to represent varying levels of water quality and habitat degradation, in-stream flow concerns and areas of future development. Further work with the planning group constructed a longer, Tier 2 list of streams that will be monitored if funding allows.

The result of these efforts was that 11 streams were selected as Tier 1 sites where monitoring will be conducted every year. These locations are shown on Figures 1 and 2. An additional 32 Sites were selected as potential Tier 2 sites, where monitoring would occur on a rotating schedule so a given site is only monitored for one year out of four. Information regarding the location and relative priority of Tier 2 sites can be found in Herrera 2010.

Tier 1 Stations

Skokomish River: The Skokomish River has the largest drainage area of any-in Hood Canal Stream watershed -and is, subsequently, the single largest freshwater input into Hood Canal. It has low residential growth potential due to moratorium on development in the floodplain; however, it is affected by forestry activities, and currently, the Skokomish River basin faces problems due to aggradation which poses concerns for future in-stream flows. The Skokomish Tribal Nation monitors water quality on a monthly basis at several sites. The US Geological Survey (USGS) and Ecology maintain flow gauging stations at a number of sites on the river.

Jorsted Creek: Jorsted Creek is representative of the many small to medium sized west shore drainages. There is currently development on Hamma Ridge within the Jorsted Creek watershed and there is moderate potential for development in the future. Jorsted Creek does not currently have any impairment listings, but fecal coliform may be of concern.

Duckabush River: The Duckabush River is one of the more pristine rivers in the Hood Canal watershed. It is also one of the larger drainages within the basin with most of its drainage area in protected wilderness or Olympic National Park. Current land use is predominately forestry with

some rural residential development near the mouth. It currently category 5 listed due to elevated temperatures. Salmon habitat in the lower reaches is rated as poor.

Big Quilcene River: The Big Quilcene River is indicative of the medium sized drainages in Jefferson County on the Northwest shore of Hood Canal. There is a category 5 temperature listing and fish passage may be of concern. Ecology has a permanent flow monitoring station on the Big Quilcene River.

Big Beef Creek: Big Beef Creek lies in one of the more developed watersheds in the Hood Canal region. Most of the land area is rural or suburban residential with only some of the watershed being forested. Residential growth potential in this region is high. There are currently category 5 listings for dissolved oxygen and temperature in Big Beef Creek. Permanent flow monitoring stations on Big Beef Creek are maintained by Ecology and USGS.

Gamble Creek: Gamble Creek is a small drainage with areas of dense development. It drains into the northern most region of Hood Canal covered by this Study in this proposed monitoring plan. This stream is representative of the small, developed streams throughout the west side of Kitsap County. Kitsap County Health District (KCHD) monitors fecal coliform bacteria on a monthly basis.

Dewatto River: The Dewatto River represents a medium sized, forested drainage in the central region of the Kitsap Peninsula. Timber harvest is ongoing within the watershed. Water quality in the Dewatto River is considered to be quite good though it does have a category 5 listing for fecal coliform. Ecology used to maintain a water quality monitoring station on the Dewatto River which it has since abandoned. KCHD monitors the upper reaches for fecal coliform bacteria on a monthly basis.

Union River: The Union River represents one of the largest drainages that flow into the North shore of the Southern arm of Hood Canal. It is included in the list of impaired waters as a category 5 stream due to low dissolved oxygen. There is a TMDL being implemented to control fecal coliform bacteria, but bacteria continue to be a concern. Development along the Union River is primarily rural residential, and is predicted to increase along with the Belfair urban growth area. Kitsap County Health District monitors a station on the Union River for Fecal Coliform.

Tahuya River: The Tahuya River represents another large drainage that flows into the North shore of the Southern arm of Hood Canal. It is category 5 listed for dissolved oxygen. The watershed is fairly undeveloped, but has the potential for more development in the future. KCHD monitors the upper reaches for fecal coliform bacteria on a monthly basis.

Big Bend Creek: Big Bend Creek is indicative of the small drainages on the South shore of the Southern arm of Hood Canal. It is currently listed as a category 5 stream due to fecal coliform contamination, and has the potential for increased residential development in the future.

Trail's End Creek: Trail's End Creek is listed as a category 5 stream due to fecal coliform levels, and represents a relatively undeveloped but developing South Shore drainage of the Southern arm.

Tier 2 Sites

Tier 2 sites have not been selected at this time. A potential list of Tier 2 sites is included in the monitoring strategy (Herrera 2010).

Sampling Process Design

Monitoring will consist of four primary components: hydrologic monitoring, water quality monitoring, invertebrate monitoring, and sediment quality monitoring.

Hydrologic Monitoring

This section provides protocols for measuring stream flow at a station with natural and/or existing artificial hydraulic controls. Construction of artificial controls is generally not an option for the salmonid bearing streams of interest in the study area. Discharge is determined by continuous measurement of stream stage, periodic area-velocity (AV) measurement of discharge, and development of a rating curve.

Station Location Selection

Desirable features for a gauging station include the following (Rantz et al. 1982):

1. Straight channel for 300 feet above and below the station;
2. Single channel without subsurface flow;
3. Stable streambed not subject to erosion or agradation and free of aquatic plants;
4. Stable banks, free of brush and tall enough to contain high flows;
5. Stable hydraulic controls over the range of stream stage, such as stable riffles at low flow or bedrock outcrops at high flow;
6. A pool present upstream of site for recording stage at very low flow and avoiding high velocities at a gauge intake;
7. Lack of tidal effects or confluence with another stream;
8. A reach near the hydraulic control where stage can be measured at all stages; and
9. Access for installation, operation, and maintenance.

In addition, an accessible, nearby site is required for making AV measurements.

Good hydraulic controls will exhibit both stability and sensitivity, the latter meaning that changes in discharge will produce a significant change in stage. Sensitivity at low flows typically

requires a relative restriction in channel width. Sensitivity at high flows requires containment by stream banks and absence of a flood zone.

Few locations will meet all requirements and a less than desirable site may be selected because of limited options. Many possible sites in the Hood Canal area are downstream, low gradient, alluvial reaches that can exhibit variable hydraulic controls, changing bed elevations, and/or bank erosion problems. Such unstable characteristics at gauging stations will require greater attention to the rating curve and more frequent AV measurements.

Stage Measurement

Stream stage should be measured to an accuracy of ±0.01 foot with one or more of the following techniques:

- Staff gauge;
- Pressure transducer;
- Bubbler; and/or
- Overhead ultrasonic meter.

A porcelain coated, steel staff gauge should be included in all installations and referenced by survey to a nearby, permanent feature. The offset between the staff gauge reading and the recorded instrument value should be monitored and used to correct the data for instrument drift.

Continuous stage measurement may be made with pressure transducers, bubblers, or ultrasonic meters. The choice of instrument and other features of the station are dependent on the desired station life, station constraints, and cost. For longevity and low operational cost, due consideration should be given to high flow velocities and possible vandalism. Telemetry (automated data collection) should be considered where financially feasible in order to lower total operational costs by reducing site visits.

Area-Velocity Measurements

For wadeable streams, discharge is measured using the 6/10s method (Rantz 1982) which assumes that mean stream velocity occurs at 60% of depth below the surface. Stream velocity is measured at the 60% depth at about 20 stations across the channel. Whenever possible, field sampling teams will make discharge measurements within the stream channel in an area that best approximates uniform flow and has minimum turbulence. To ensure discharge measurements made in stream channels are consistent from one site visit to the next, field sampling teams will drive steel rods in each stream bank at the onset of monitoring to serve as reference points for all subsequent discharge measurements.

To measure discharge, field sampling steams will stretch a surveyor's tape between the steel rods. Channel depth, water depth, and current velocity will then be recorded at each of 10 to 25 intervals along the cross-section (approximately one measurement per 0.5 feet). Velocity will

be recorded according to the six-tenths-depth method (Rantz, 2001) using one of the current meters listed above. Stream depths measured on the in-stream staff gage will be read at the beginning and end of each discharge measurement to aid in correcting measurements made during changing conditions, and to facilitate the development of stream discharge rating curves. Field sampling teams will record velocity and water depth measurements on standardized field forms. Stream discharge will then calculated by multiplying the velocity measurement by the cross-sectional area of each interval and summing the results.

Discharge is calculated as:

 , where

Q = discharge,

i = station number,

n = number of stations,

x_i = station position,

v_i = measured velocity at station i, and

d_i = depth at station i.

Many velocity meters have capability to calculate discharge automatically. Measurement accuracy for the area-velocity technique is estimated to be +/- 3 percent.

Velocity Meters

Velocity meters should be calibrated in a test tank. Acoustic doppler current profilers have a low end velocity rating of 0.01 fps, whereas mechanical meters (e.g., swoffer and pygmy types) are limited to about 0.25 fps. Mechanical meters should also be checked for performance roll-off below 1 fps. Specific calibration requirements are dependent upon meter type (e.g., Swoffer meters require individual calibration of each propeller/axle assembly) and should be documented in preparation of the final QAPP for the program.

Stage-Discharge Rating Curves

Stage-discharge rating curves should be developed from a minimum of six flow measurements per year over a range of stages. Discharge measurements should be taken as near the gauging stations as feasible. Generally, the ability to measure high flows at a site will be limited by wadeability of the stream.

Rating Curves

Rating curves predict discharge from stage based on an empirical mathematic formula. For the portion of the rating curve determined by data, any formula can be used that fits the data. For extrapolation of the rating curve beyond the highest measured flow, a power-law equation has been used on some Hood Canal streams (Aspect Consulting, 2005). In that work, stage-discharge data for each stream were fit with a power-law equation (Maidment, 1993) of the form:

 , where

Q = discharge,

h = stage,

a = stage at which discharge is zero, and

N = constant related to cross-sectional shape or the stream channel.

Shifts in hydraulic control have been observed on several Hood Canal streams after high flow events. AV measurements should be taken with sufficient frequency to identify such changes. For a stable hydraulic control, the frequency of discharge measurements may be reduced after the rating curve is developed.

Peak Discharges

Discharge at stages above those bracketed by the area-velocity measurements can be estimated by extrapolation of the rating curve. The extrapolation can be confirmed or adjusted if necessary by calculation of discharge using a slope-area method such as the Manning equation (Rantz, 1982). The channel section and longitudinal slope will need to be surveyed in order to calculate cross sectional area, hydraulic radius, and channel gradient. Data extrapolated outside the rating curve should be flagged.

Water Quality Monitoring

Water samples will be collected 10 times per year at all Tier 1 stations. The exact sampling dates are not fixed, but will occur six times between the middle of November and the middle of February, and one time in each July, August, September, October and November. Anywhere between two and eight Tier 2 sites from a single sub-region (Figures 1, 2) may be monitored each year. Sampling at these sites would occur coincident in time with Tier 1 station monitoring. The next year, a new sub-region would be selected for monitoring. This would be set up on a 4 year rotating cycle so that stations in the original sub-region would be monitored again 4 years later. Consistency in sampling dates between years is important so the sampling schedule that is established in the first year should be replicated in following years. Table 1 outlines the parameters measured as well as measurement quality objectives and reporting limits. Table 4

Table 4. Methods and reporting limits for water and sediment quality analysis

Water Quality Analytes and Methods										
Analyte Group	Analyte	Analysis Method	Method Number	Field Sample Container	Pre-filtration Holding Time	Total Holding Time	Field Preservation	Laboratory Preservation	Reporting Limit/Resolution	Units
Conventional Parameters	*Field Analysis*									
	pH	Field Meter	N/A	N/A	N/A	N/A	N/A	N/A	1-14 SU	pH
	Dissolved Oxygen	Field Meter	N/A	N/A	N/A	N/A	N/A	N/A	0.1-15	mg/L
	Temperature	Field Meter	N/A	N/A	N/A	N/A	N/A	N/A	0.01°C	°C
	Conductivity	Field Meter	N/A	N/A	N/A	N/A	N/A	N/A	1	µmoh/cm
	Turbidity	Field Meter	N/A	N/A	N/A	N/A	N/A	N/A	1	NTU
	Laboratory Analysis									
	Total suspended solids	Gravimetric	SM 2540D	1 L HDPE	7 days	7 days	Maintain ≤ 6°C	Maintain ≤ 6°C	1.0	mg/L
	BOD_{20}[a]	Membrane Electrode	SM5120B	1 L HDPE	N/A	48 hours	Maintain ≤ 6°C	Maintain ≤ 6°C	2.0	Mg/L
Bacteria	Fecal Coliform	Multiple Tube Fermentation	SM 9221E	250 mL glass/ plastic auto-claved bottle	N/A	6 hours (accepted) 24 hours (estimated)	Maintain ≤ 6°C	Maintain ≤ 6°C	2min, 2E6 max	CFU
Nutrients	Total phosphorus	Digestion / Colorometric	EPA 365.3 or 365.4	500 mL HDPE	N/A	28 days	Maintain ≤ 6°C	Maintain ≤ 6°C H_2SO_4 to pH < 2	0.01	mg/L
	Ortho-phosphate phosphorus [a]	Colorometric	EPA 365.1	500 mL amber glass	24 hours	48 hours	Filter (.45–micron syringe) Maintain ≤ 6°C	Maintain ≤ 6°C H_2SO_4 to pH < 2	0.005	mg/L
	Total Nitrogen	Digestion / Colorometeric	EPA 353.2	500 mL HDPE	N/A	28 days	Maintain ≤ 6°C	Maintain ≤ 6°C H_2SO_4 to pH < 2	0.1	mg/L
	Nitrate + nitrite nitrogen[a]	Colorometric	EPA 353.2	500 mL HDPE	48 hours	28 days	Maintain ≤ 6°C	Maintain ≤ 6°C H_2SO_4 to pH < 2	0.01	mg/L
Sediment Quality Analytes and Methods										
Metals	Priority Pollutant Metals	ICP	EPA 200.7	Glass or Teflon Jar	N/A	6 months	Maintain ≤ 6°C	Maintain ≤ 6°C	.1-50	mg/KG
Herbicides	Chlorinated Herbicides	Gas Chromotography	EPA 8151	Glass or Teflon Jar	N/A	7 days	Maintain ≤ 6°C	Maintain ≤ 6°C	.5-250	µg/KG
Pesticides	Chlorinated Pesticides	Gas Chromatography	8081	Glass or Teflon Jar	N/A	7days	Maintain ≤ 6°C	Maintain ≤ 6°C	1.7-170	µg/KG

[a] If Tier 2 monitoring occurs, these analytes were identified as optional.

lists methods and reporting limits for the analyses conducted on water samples collected at Tier 1 sites.

Field Sampling Procedures

Water Quality Sample Collection

Grab sampling will be used for all water quality sample collection for this project. Prior to sampling events, field personnel will obtain clean/sterile sample bottles from the analytical lab. 250 mL 1 amber glass bottles will be used for bacteria sampling and 500, or 1000 mL HDPE bottles will be used for chemical and physical parameter analysis.

- Fill bottle by submerging the sample bottle 6 inches below the water surface (or at mid-depth if the water depth is less than 1 foot) at a point near the center of the stream channel and upstream of the sampler.
- Orient the sample bottle opening down as it is initially submerged and then slowly oriented upstream (against flow) of the sampler while filling at the proper depth. Do not let the sample bottle get too near the stream substrate.
- Rinse bottle three times in water to be sampled (if sample contains no preservative).
- Under low flow conditions (e.g., velocity less than 0.1 feet per second), move the sample bottle slowly upstream while filling.
- After removal of the bottle from the water, discard a small portion of the sample (leaving a small headspace) to allow for proper mixing before analysis.
- Place bottle in cooler and maintain at or below 6ºC until delivered to an analytical lab.

Field Filtering

Field filtering will not be done. Special precautions should be made to insure soluble phosphorus and nirate+nitrite samples are delivered to the laboratory and filtered within 24 hours. Samples that do not meet this requirement should be marked as estimated values or rejected as per the data quality objective.

Water Quality Field Meters

Temperature, pH, DO, turbidity and conductivity may all be measured in the field with properly calibrated meters. Calibration of field meters will occur as recommended by the manufacturer.

At each site a water quality probe will be held upstream from the entry point for at least two minutes or until measurements stabilize. Parameters measured, site location, and date and time will be recorded on field data sheets.

Sediment Chemistry Monitoring

Sediment samples will be collected annually from the 11 Tier 1 sites for analysis of selected pesticides, herbicides and metals. A specific list of parameters and reporting limits is reported in Table 4. The methods listed below will be used when collecting sediment samples at monitoring locations.

Sediment samples will be collected between late June and the end of July when stream flows have decreased enough to allow formation of good depositional areas for of the same sediment sampling. All samples should be collected from depositional areas upstream of tidal influence. This may require baseline measurements of salinity or conductivity to identify the extent of the "salt wedge" in each stream. Three discrete samples will be collected at each station. Each grab sample will be placed into a stainless steel container and field observations recorded about color, odor, and general soil characteristics. Once these observations are recorded, the contents of the bowl should be mixed with a stainless steel spoon until uniform in texture and appearance. The contents of the container will be transferred to an appropriately cleaned glass or Teflon jar and labeled. When a field replicate is required, it should be collected as a subsample homogenized sample. All sediment samples will be placed in a cooler on ice until they are delivered to the laboratory or can be put under more permanent refrigeration.

After each stream is sampled, the equipment will be thoroughly washed with a non-phosphate detergent, rinsed with dilute acid and rinsed with distilled water.

Macroinvertebrate Sampling

Macroinvertebrate sampling will be conducted biennially in riffle areas adjacent to all Tier 1 monitoring stations. Additionally Macroinvertebrate sampling may occur at Tier 2 stations in the years that they are monitored for water quality. Sampling will be conducted between July 1 and October 15th when these organisms are still in larval form.

Macroinvertebrates will be collected from riffle habitats according to the Department of Ecology procedures for benthic macroinvertebrate monitoring *Benthic Macroinvertebrate Biological Monitoring Protocols for Rivers and Streams* (Plotnikoff and Wiseman, 2001). Below is a summary of the protocols:

- Macroinvertebrates will be collected from riffle habitats using a D-Frame kicknet (500 µm net mesh) sampling a streambed area of 0.19m^2.

- Three replicate samples will be combined into one composite sample.
- Large substrate material will be removed and scrubbed and streambed agitated to stir aquatic macroinvertebrates into the water column for collection.
- All collected samples will be stored in ethanol filled containers. Replicate composite samples samples will be collected and stored in separate containers.
- All samples will be stored in 85% ethanol and labeled with stream name, location, habitat type (i.e. riffle), date, sample number and collectors name.

Quality Control

To ensure that the data quality objectives for this study are met, quality control procedures are identified in separate subsections below for field and laboratory activities. The overall objective of these procedures is to ensure that data collected for this project are of a known and acceptable quality.

Field Quality Control Procedures

Quality control procedures that will be implemented for field activities are described in the following subsections. Filed quality control includes routine instrument maintenance and calibration; field duplicate collection, and proper sample handling.

Instrument Maintenance and Calibration

Routine maintenance, calibration and operational inspections will be performed to ensure that the field equipment is functioning properly.

Flow Monitoring Equipment

The calibration of automated flow measurement devices will be checked during every routine site visit by measuring the depth of water (if present) at the station and adjusting the recorded level to match. If no water is present at the station and the flow measurement device is a bubbler or other level sensing device, then that device may be calibrated using a known depth in a container of water. Instrument maintenance and calibration activities will be documented on standardized field forms.

Water Quality Field Meters

Water quality field meters will be calibrated at the beginning of each day by following the manufacturer's guidelines for calibration of the specific meter and probe that will be used.

Field Notes

During visits to each monitoring station, the following information will be recorded on a waterproof standardized field form.

Site Name

Date/time of visit and last sample collected

Name(s) of field personnel present

Weather and flow conditions

Field Duplicates

Field duplicates will be collected at a sufficient frequency to represent a minimum of 10 percent of the total number of samples collected during each sampling event. The number of field duplicates to be collected during the sampling season related to Tier 1 sampling is listed in Table 5. Field duplicates will be collected by splitting collected samples with a combination cone and churner splitter. All duplicate samples will be submitted to the laboratory and labeled as separate (blind) samples. The resultant data from these samples will then be used to assess variation in the analytical results that is attributable to environmental (natural), sub-sampling, and analytical variability.

Sample Handling

All sample bottles will be transported in coolers with ice and kept below 6 degrees Celsius until delivery to the laboratory. The temperature of the samples will be measured upon sample delivery and recorded on the chain-of-custody form.

Sample Identification and Labeling

All sample containers will be labeled with the following information using indelible ink and labeling tape:

Station name Date of sample collection (year/month/day: yyyy/mm/dd)

Time of sample collection (international format [24 hour])

Field personnel initials.

QA samples (field duplicates and blanks) will be labeled as QA1, QA2, etc. for delivery to the laboratory, but field staff will maintain a cross-check list of which stations and sample types the QA samples represent. When results are returned from the laboratory, field lead will associate full label information with the results, and populate database fields for the QA sample and type.

Waterproof labels will be placed on dry sample container lids by self-adhesion or with tape. Waterproof labeling tape may be employed. Any written marks will be made with waterproof ink.

Sample Containers and Preservation

Clean, decontaminated water sample bottles will be obtained from the analytical laboratory in advance of each sampling event. Spare sample bottles will be carried by the sampling team in case of breakage or possible contamination. Sample containers and preservation techniques will follow U.S. EPA (2007) guidelines and are specified in Table 4.

Table 5. Anticipated annual number of samples and associated quality assurance requirements for each study parameter*.

	Parameter	Samples per Station	Number of Stations	Total Number of Samples	Laboratory Method Blanks	Laboratory Control Standard	Matrix Spike	Field Duplicates	Lab Duplicates
Water Quality Control									
Conventional Parameters	Total suspended solids	10	11	110	1batch [a]	1/batch [a]	NA	10[b]	1/batch [a]
	Turbidity	10	11	110	1batch [a]	1/batch [a]	1/batch [a]	10[b]	1/batch [a]
	Conductivity	10	11	110	1batch [a]	1/batch [a]	NA	10[b]	1/batch [a]
	BOD_{20}	10	11	110	1batch [a]	1/batch [a]	NA	10[b]	1/batch [a]
Bacteria	Fecal Coliform	10	11	110	1batch [a]	1/batch [a]	NA	10[b]	1/batch [a]
Nutrients	Total phosphorus	10	11	110	1batch [a]	1/batch [a]	NA	10[b]	1/batch [a]
	Ortho-phosphate phosphorus	10	11	110	1batch [a]	1/batch [a]	NA	10[b]	1/batch [a]
	Total nitrogen	10	11	110	1batch [a]	1/batch [a]	NA	10[b]	1/batch [a]
	Nitrate + nitrite nitrogen	10	11	110	1batch [a]	1/batch [a]	NA	10[b]	1/batch [a]

NA: not applicable.

[a] Laboratory QA samples will be analyzed with each batch of samples submitted to the laboratory for analysis. A laboratory batch will consist of no more than 20 samples.

[b] Field duplicates will be collected and analyzed for at least ten percent of the total number of submitted sample, at a minimum of 1 set of field duplicates for each monitoring event.

Chain-of-Custody Record

A chain-of custody record will be maintained for each sample batch listing the sampling date and time, sample identification numbers, analytical parameters and methods, persons relinquishing and receiving custody, dates and times of custody transfer, and temperature of samples upon delivery.

Laboratory Quality Control Procedures

Method Blanks

Method blanks consisting of de-ionized and micro-filtered pure water will be analyzed with every laboratory sample batch. A laboratory sample batch will consist of no more than 20 samples and may include samples from other projects. The total number of method blanks anticipated for this study is shown in Table 5 by parameter. Blank values will be presented in each laboratory report.

Control Standards

Control standards for each parameter will be analyzed by the laboratory with every sample batch. A laboratory sample batch will consist of no more than 20 samples and may include samples from other projects. The total number of control standards anticipated for this study is shown in Table 5 by parameter. Raw values and percent recovery (see formula in the Quality Objectives section) for the control standards will be presented in each laboratory report.

Matrix Spikes

For applicable parameters, matrix spikes will be analyzed by the laboratory with every sample batch. A laboratory sample batch will consist of no more than 20 samples and may include samples from other projects. The total number of matrix spikes anticipated for this study is shown in Table 5 by parameter. Raw values and percent recovery (see formula in the Quality Objectives section) for the matrix spikes will be presented in each laboratory report.

Laboratory Duplicates

Laboratory duplicates for each parameter will be analyzed for specifically labeled QA samples submitted with every sample batch. This will represent no less than 10 percent of the project submitted samples. The total number of laboratory duplicates anticipated for this study is shown in Table 5 by parameter. Raw values and relative percent difference (see formula in the Quality Objectives section) of the duplicate results will be presented in each laboratory report.

Data Management Procedures

Hydrologic data will be downloaded each time a site is visited. Data from each monitoring station will be imported directly into a database for subsequent analysis and archiving purposes. These data will be immediately checked for evidence of an equipment malfunction or other operational problem. Gaps in flow data may need to be interpolated; if this occurs, data will be stored and presented in a manner that makes it clear which data are from measurement, and which have been interpolated. These summary statistics will ultimately be stored in a database (e.g. Microsoft Access®) or spreadsheet (e.g. Microsoft Excel®) form with other water quality data collected during the project (see description below).

The selected laboratory will report the analytical results within 30 days of receipt of the samples. The laboratory will provide sample and quality control data in standardized reports that are suitable for evaluating the project data. These reports will include all raw data including raw quality assurance data, and all quality control results associated with the data. The reports will also include a case narrative summarizing any problems encountered in the analyses, corrective actions taken, changes to the referenced method, and an explanation of data qualifiers. Laboratory analytical and QA results will be delivered from the laboratory in both electronic and hardcopy form.

Analytical data for the project will be stored by individual monitoring groups in database (e.g., Microsoft Access) or spreadsheet (e.g., Microsoft Excel) format. A continuous hydrologic record will also be stored so that annual loading assessments can be included. On an annual or semi-annual basis, the appointed data manager will upload all sampling data to Ecology's EIM database. Prior to upload, the data manager will perform an independent review of the data to ensure that all sample values are entered without error. This review will consist of checking that all laboratory data are entered into the database correctly. Results from this review will be documented in a data entry review worksheet.

Data Verification and Validation

Data verification and validation will be performed on the hydrologic, water quality, and sediment data that are collected through the duration of this project. The specific procedures that will be used to verify and validate each type of data are described in the following sections.

Verification and Validation Methods for Hydrologic Data

The verification and validation process for hydrologic data will involve the following:

- The available discharge from the monitoring stations will be verified based on comparisons to similar streams in the watershed over the same study period. Gross anomalies (e.g., data spikes), gaps, or inconsistencies that are identified through this review will be investigated to determine if there are quality assurance issues associated with the data that limit their usability.

- If minor quality assurance issues are identified in any portion of the discharge record or in the water level data from a particular station and storm event, the data from that station and event will be considered as an estimate and assigned a (*j*) qualifier. If major quality assurance issues are identified in any portion of the data from a particular station over a known period of time, this data will be rejected and assigned an (*r*) qualifier. Estimated values will be used for evaluation purposes while rejected values will not.

Verification and Validation Methods for Chemistry Data

Data will be reviewed and audited by the monitoring group managers within seven business days of receiving the results from the field or laboratory. This review will be performed to ensure that all data are consistent, correct and complete, and that all required quality control information has been provided. Specific quality control elements for the data (Table 1) will also be examined to determine if the MQOs for the project have been met. Results from these data validation reviews will be summarized in quality assurance worksheets that are prepared for each sample batch. Values associated with minor quality control problems will be considered estimates and assigned qualifier listed in Table 6. Values associated with major quality control problems will be rejected and qualified *R*. Estimated values may be used for evaluation purposes, while rejected values will not be used. The following sections describe in detail the data validation procedures for these quality control elements:

- Methodology
- Holding times

- Blanks
- Reporting limits
- Duplicates
- Matrix spikes and matrix spike duplicates
- Calibration and control standards
- Sample representativeness.

Table 6. Data qualifiers and definitions.

Data Qualifier	Definition	Criteria for Use
J	Value is an estimate based on analytical results.	MQOs for field duplicates, laboratory duplicates, matrix spikes, laboratory control samples, holding times, or blanks have not been met.
R	Value is rejected based on analytical results.	Major quality control problems with the analytical results.
Jj	Value is an estimate based on analytical results	Analytical sampling criteria have not been met, but data is still usable.
U	Value is below the reporting limit.	Based on laboratory method reporting limit.
UJ	Value is below the reporting limit and is an estimate based on analytical results.	Based on laboratory method reporting limit; MQOs for analytical results have not been met.
Ur	Value is below the reporting limit and is rejected based on storm sampling criteria.	Based on laboratory method reporting limit; Hydrograph is compromised from gage error, and has rendered the EMC non-representative.

Methodology

Methodologies for analytical procedures will follow U.S. EPA approved methods (APHA et al. 1992; U.S. EPA 1983, 1984) specified in Table 4. Field procedures will follow the methodologies described in this quality assurance project plan. Any deviations from these methodologies must be approved by the Project Manager and documented in an addendum to this QAPP. The database will include a field for identifying analytical method. Deviations that are deemed unacceptable will result in rejected values (*R*) and will be corrected for future analyses.

Holding Times

Holding times for each analytical parameter in this study are summarized in Table 4. Holding time compliance will be assessed by comparing sample collection dates and times to filtration (pre-filtration) and analytical dates and times (post-filtration or total). Sample collection times will be based on the date and time that the last aliquot was collected, but date and time of start of sampling will be recorded as well.

Samples requiring filtration should be filtered within 24 hours of collection of the last aliquot. Standard methods require that orthophosphorus samples be filtered within 15 minutes of

collection. Meeting this holding time goal would be difficult for this project given the difficulty of field filtering logistics. Consequently, a proxy holding time of 24 hours will be used for this project. Orthophosphate samples exceeding the 24-hour limit will be rejected (*R*). Standard methods require that fecal coliform samples be prepared for analysis within 6 hours of collection, but due to the difficulty to meet this holding time, a proxy holding time of 24 hours will be used. Samples held beyond this time will be rejected.

- For analytes with holding times in excess of 7 days:
  - Data from samples that exceed the specified maximum holding times by less than 48 hours will be considered estimates (*J*). Data from samples that exceed the maximum post-filtration holding times by more than 48 hours will be rejected values (*R*).
- For analytes with holding equal to or less than 7 days:
  - Data from samples that exceed the specified maximum holding times by less than 24 hours will be considered estimates (*J*) (orthophosphate will receive an *R*). Data from samples that exceed the maximum post-filtration holding times by more than 24 hours will be rejected values (*R*).

Method Blanks

Method blank values will be compared to the MQOs that have been identified for this project (see Table 1). If an analyte is detected in a method blank at or below the reporting limit, no action will be taken. If blank concentrations are greater than the reporting limit, the associated data will be labeled with a *U* (in essence increasing the reporting limit for the affected samples), and associated project samples within 5 times the de facto reporting limit will be flagged with a *J*. (Grepogrove 2007).

Reporting Limits

Both raw values (i.e., values between the method detection limit and the reporting limit) and reporting limits will be presented in each laboratory report. If the proposed reporting limits are not met by the laboratory, the laboratory will be requested to reanalyze the samples and/or revise the method, if time permits. Proposed reporting limits for this project are summarized in Table 4.

Duplicates

Duplicate results exceeding the MQOs for this project (see Table 1) will be recorded in the raw data tables, and noted in the quality assurance worksheets; and associated values will be flagged as estimates (*J*). If the objectives are severely exceeded (e.g., more than twice the objective), then associated values will be rejected (*R*).

Matrix Spikes

Matrix spike results exceeding the MQOs for this project (see Table 1) will be noted in the quality assurance worksheets, and associated values will be flagged as estimates (*J*). However, if the percent recovery exceeds the MQOs and a value is less than the reporting limit, the result will not be flagged as an estimate. Nondetected values will be rejected (*R*) if the percent recovery is less than 30 percent.

Control Standards

Control standard results exceeding the MQOs for this project (see Table 1) will be noted in the quality assurance worksheets, and associated values will be flagged as estimates (*J*). If the objectives are severely exceeded (e.g., more than twice the objective), then associated values will be rejected (*R*).

Data Quality Assessment

Data Usability Assessment

The quality assurance officer will provide an independent review of the water quality QC data from each sampling event in accordance with the MQOs that have been identified in this QAPP. The results will be presented in a data quality assessment report that will be prepared for each monitoring year. The report will summarize quality control results, identify when data quality objectives were not met, and discuss the resulting limitations, if any, on the use or interpretation of the data. Specific quality assurance information that will be noted in the data quality assessment report includes the following:

- Changes in and deviations from the monitoring and quality assurance plan
- Results of performance and/or system audits
- Significant quality assurance problems and recommended solutions
- Data quality assessment results in terms of precision, bias, representativeness, completeness, comparability, and reporting limits
- Discussion of whether the quality assurance objectives were met, and the resulting impact on decision-making
- Limitations on use of the measurement data.

To assess the quality of the flow data flow QA worksheets will be compiled for inclusion in the annual data report. The QA worksheets will be summarized and presented in a tabular format. A brief narrative accompanying the table will summarize quality control results, identify when data quality objectives were not met, and discuss the resulting limitations, if any, on the use or interpretation of the data.

Data Evaluation

Specific procedures for evaluating the collected data are beyond the scope of this effort. However, the following general evaluation needs have been identified:

Water Quality Data

- Calculate summary statistics (e.g., range, mean, standard deviation) for individual sites each year.
- Calculate summary statistics for all sites for each year to allow general between site comparisons. Over time, compare results between years to evaluate long term trends.
- Identify water quality violations or improvements at individual sites.
- Calculate pollutant loads (pounds per year) and pollutant yields (pounds per square mile of watershed) for the winter and summer monitoring periods for individual sites. Compare these between sites. Over time, compare results between years to identify long term trends.
- Calculate the Water Quality Index (WQI) for each site and use this for further comparison between sites and to evaluate long term trends.

Sediment Quality Data

- Calculate summary statistics using data from all sites to identify problematic sites.
- Over time, use the results from individual sites to evaluate trends at that site.
- Compare all sediment results to applicable sediment quality standards in (WAC 172.204.320) (For Washington Administrative Code: Chapter 172.204 Section 320)

Macroinvertebrate Samples

- Calculate BIBI scores based on methods found in King County 2009 for individual sites.

- Over time, evaluate long term trends in BIBI scores for individual sites and watershed wide.

Flow Data

- Calculate standard flow statistics (maximum, minimum, median, maximum 7 day moving average, minimum 7 day moving average) for individual sites.
- Over time, perform trend analysis for flow data for individual streams and compared to watershed wide trends.
- Extrapolate flows to ungauged streams in similar geo/climatic regions.

Reporting Procedures

The data manager will prepare an Annual Monitoring Report. This report will include monitoring data collected during the water year (October-September) and utilize to the extent appropriate past data to evaluate trends. The report will specifically include the following information:

- Summary information, including the location drainage area size, and hydrology for each site
- A comprehensive data and QA/QC report for each component of the monitoring program, with an explanation and discussion of the results of each monitoring project
- A summary of data evaluation results as described above (e.g., summary statistics, site comparisons, and comparisons to standards, WQI and BIBI scores etc.).

As the dataset develops, trend analysis describing statistical differences in chemical loads, concentrations, hydrologic, and biologic parameters for each site should be undertaken. This might initially include simple time series comparisons, but through time should include more rigorous statistical tests.

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